Water Chemistry Upstream and Downstream of Coal Mines in the MacLeod River System of west-central Alberta

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Image: Teck

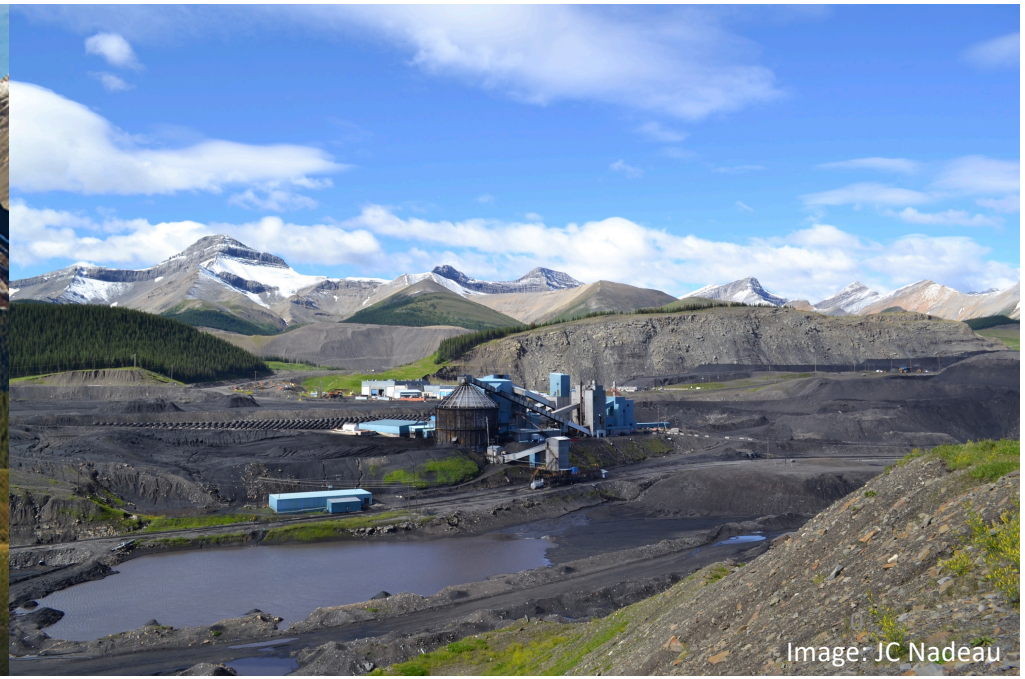


Image: JC Nadeau

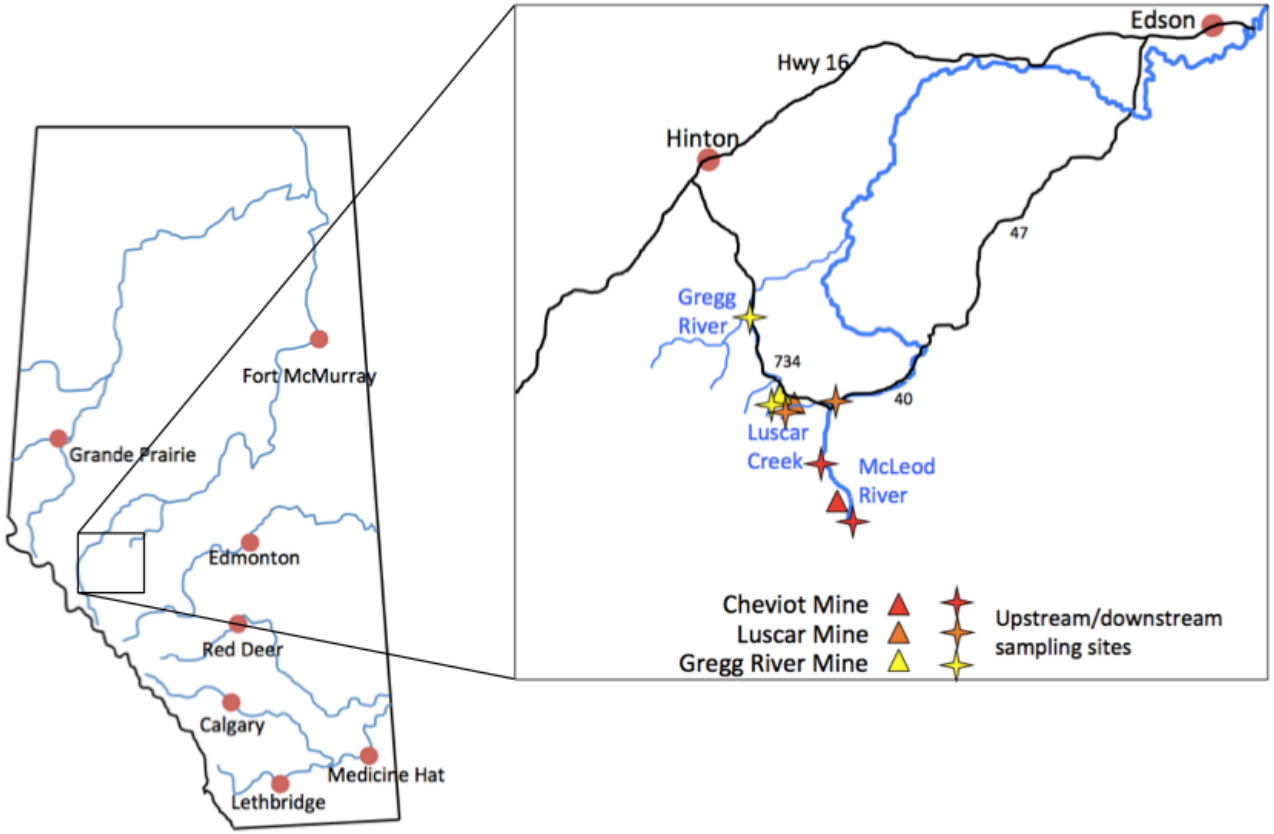
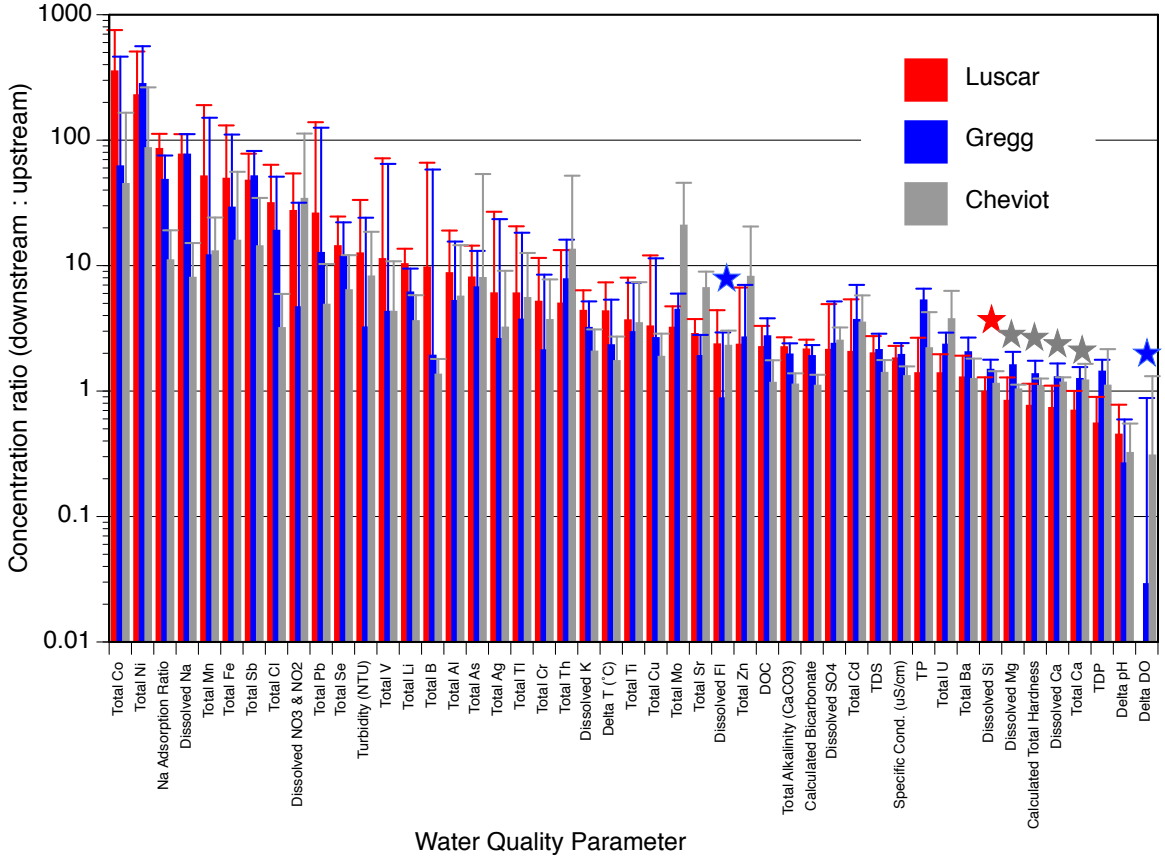


Figure 1. Three coal mines (Cheviot, Luscar and Gregg River) in the upper McLeod River watershed, and Alberta Environment and Parks' associated upstream and downstream water quality monitoring sites chosen to identify effects of the coal mine operations on downstream water quality

Preface

- From 1998 to 2016, Alberta Environment and Parks conducted seasonal water quality sampling immediately upstream and downstream of three large coal mines approximately 50 km south of Hinton, in the headwaters of the McLeod River watershed in west-central Alberta
- Mining began at Luscar and Gregg River in 1969 and 1982, and reclamation began in 1971 and 1982
- Active mining ceased at the Gregg River mine in 2000, and at the Luscar mine in 2004
- Mining operations at Cheviot Mine began in 2005 and continued until 2016, and the Luscar mine processing plant and site remained in operation for processing coal from the Cheviot mine
- By 2017, 60% of the Luscar mine's 53 km^2 area was reclaimed, and 99% of Gregg River mine's 37 km^2 area was reclaimed, although not certified by the AER (Beale and Boyce 2020)

Figure 2. Ratio of downstream concentrations to upstream concentrations, in rivers or creeks downstream of three coal mines in west-central Alberta's McLeod River watershed (1998-2016 for Luscar and Gregg River mines; 2005-2016 for Cheviot Mine).



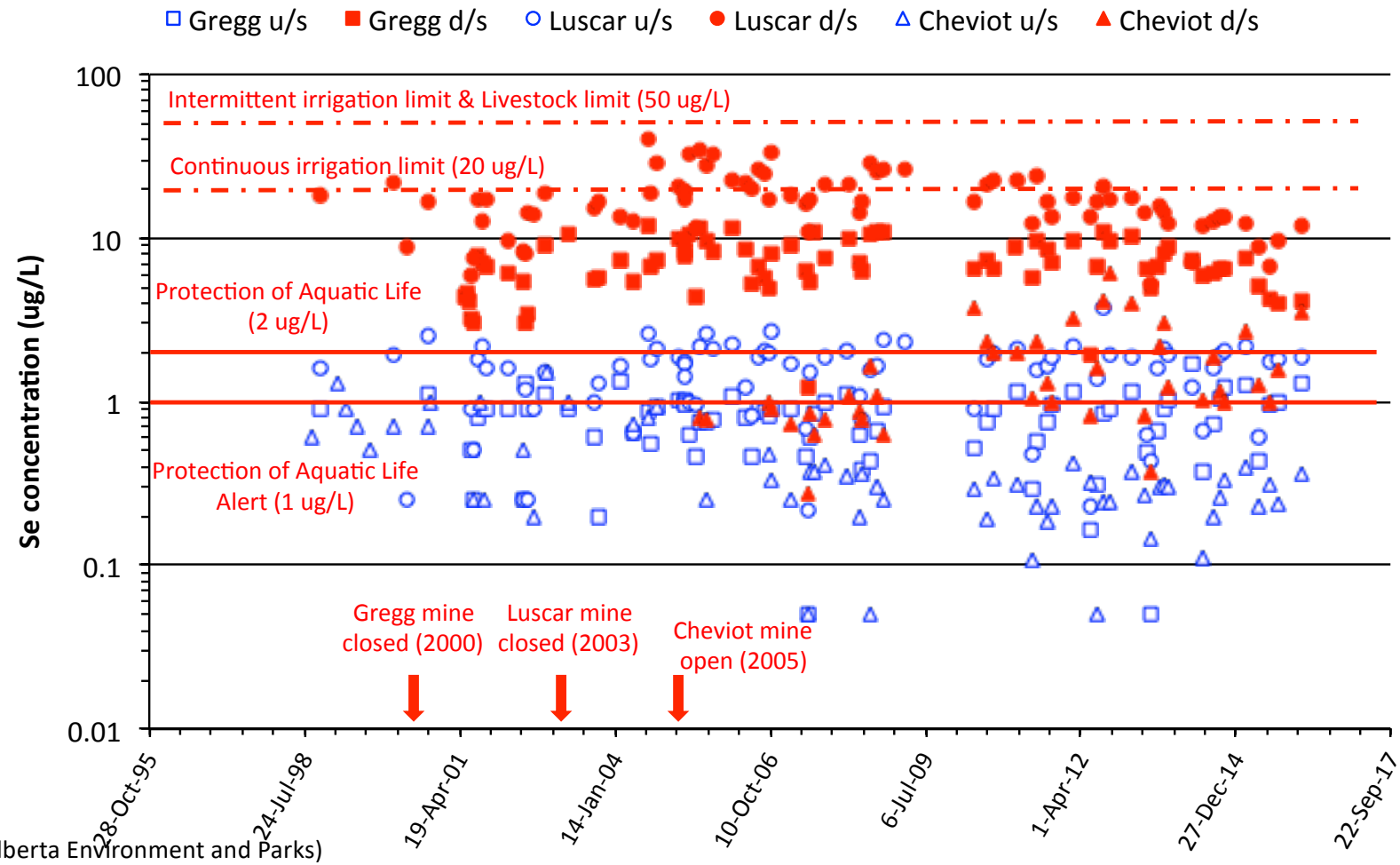
All ratios are significant at the (P<0.05) level, unless where indicated by a star, coded by colour to match the three mines. Values for temperature, pH and dissolved oxygen (DO) from upstream to downstream reflect absolute changes, rather than ratios.

(Data source: Alberta Environment and Parks)

Average ratio by which concentrations of metals, nutrients and other water quality parameters increased downstream of coal mines, relative to upstream at unimpacted sites

Element or Chemicals	Luscar Creek	Gregg River	Cheviot Mine (McLeod River)
Co	353.2	61.8	44.7
Total Ni	228.0	280.0	140.8
Na	76.7	76.6	8.2
Mn	51.4	12.1	13.0
Sb	47.5	49.2	14.3
Cl	31.4	18.9	3.2
Total Fe	49.3	29.0	23.7
NO3 & NO2	27.2	4.7	37.9
Pb	26.0	12.6	4.9
Se	14.3	11.8	6.4
Turbidity	12.5	3.2	8.2
V	11.3	4.3	4.3
Li	10.3	6.1	3.6
B	9.7	1.9	1.4
Al	8.7	5.2	5.7
As	8.0	6.7	8.0

Concentrations of selenium (Se) upstream and downstream of coal mines in west-central Alberta



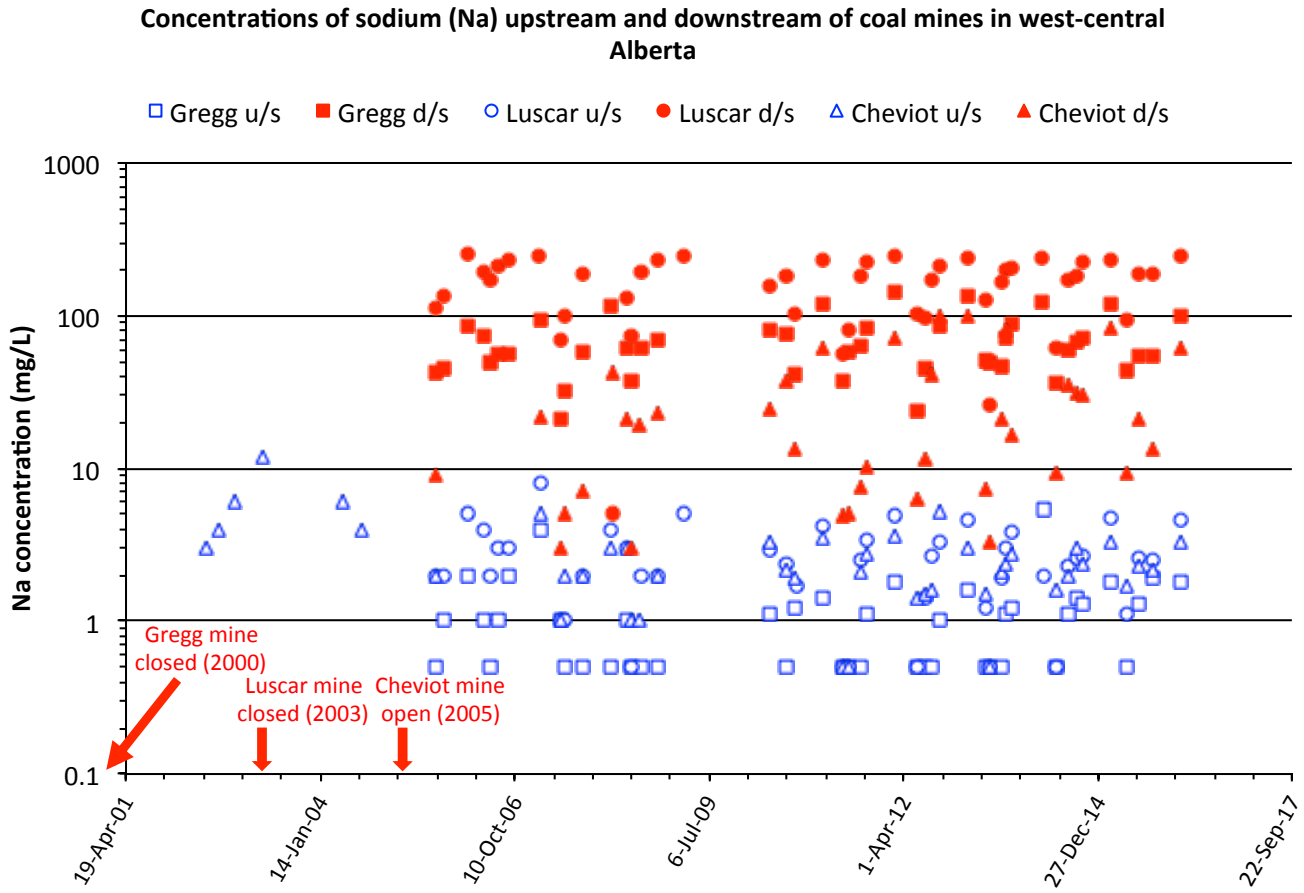
(Data source: Alberta Environment and Parks)

Frequency of exceedances of Protection of Aquatic Life water quality limits in Alberta Environment & Park's monitoring program upstream and downstream of coal mines in west-central Alberta, between ~2000 and 2016 (2005 and 2016, for Cheviot Mine) (Source: Alberta Environment and Parks)

Less than 5% of samples exceed limits
5% to 40% of samples exceed limits
More than 40% of samples exceed limits

		Gregg		Luscar		Cheviot	
		REF	Downstream	REF	Downstream	REF	Downstream
	% Alert >1 ug/L)**	24%	100%	76%	100%	0%	58%
Se	% PAL (>2 ug/L)**	0%	97%	25%	100%	0%	26%
Chlorine	% Chronic	31%	99%	32%	100%	0%	45%
	% Chronic	22%	51%	18%	68%	33%	79%
Al (ug/L)	% Acute	12%	35%	9%	48%	24%	51%
	% Chronic	4%	4%	0%	0%	0%	3%
Cd	% Acute	0%	0%	0%	0%	0%	0%
	% Chronic	4%	4%	0%	1%	0%	3%
Cr	% Acute	0%	0%	0%	0%	0%	0%
	% Chronic	0%	7%	0%	0%	0%	3%
Cu	% Acute	0%	0%	0%	0%	0%	0%
Pb	% Chronic	4%	4%	0%	0%	0%	3%
Zn	% Chronic	0%	4%	0%	1%	0%	2%

Sodium (Na) concentrations upstream and downstream of coal mines in west-central Alberta (Source: Alberta Environment and Parks)



(Data source: Alberta Environment and Parks)

“Sodium Adsorption Ratio”

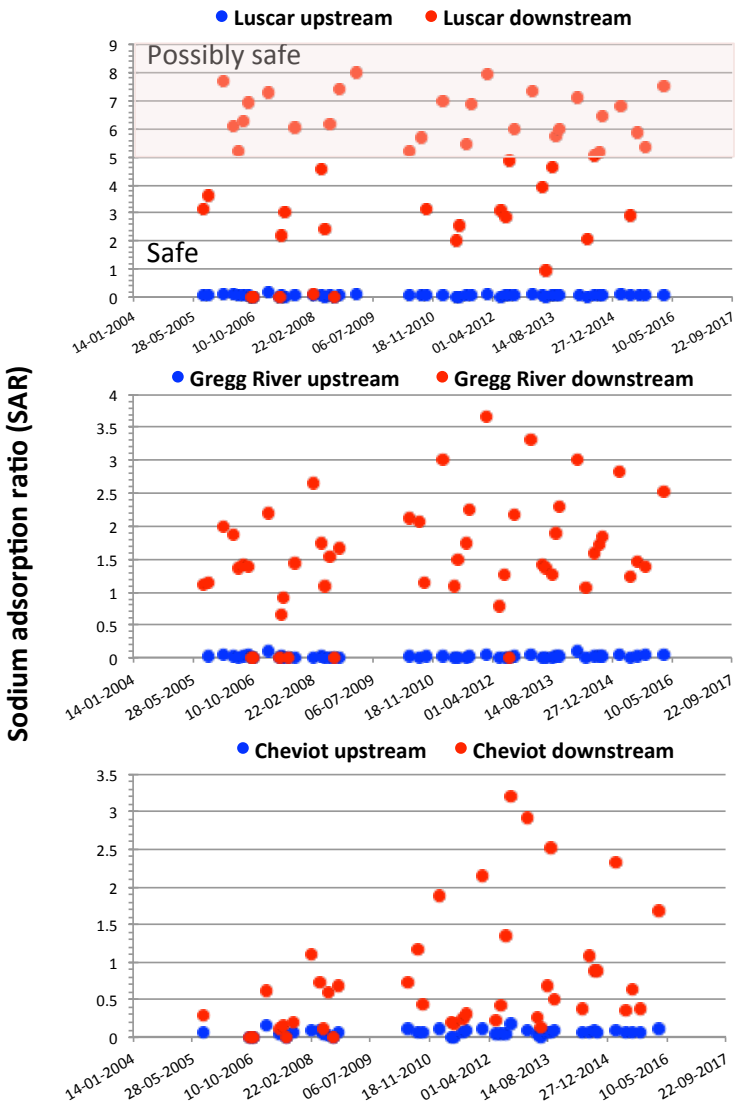
- one of the indicators of irrigation water quality commonly used

$$SAR = \frac{Na}{\sqrt{\frac{(Ca + Mg)}{2}}}$$

- if sodium concentrations increase disproportionately more than calcium and magnesium, then SAR increases
- Alberta Environment:
  - water with SAR < 5 = safe for irrigation use
  - SAR >10 = hazardous for irrigation use
  - 5 < SAR < 10 = "possibly safe" for irrigation purposes (i.e., possibly hazardous)

On average, relative to upstream samples, SAR increased by:

- Luscar mine: 5.4 units (> 5 = possibly unsafe)
- Gregg River mine: 2.0 units
- Cheviot mine: 0.8 units (and increasing over time)



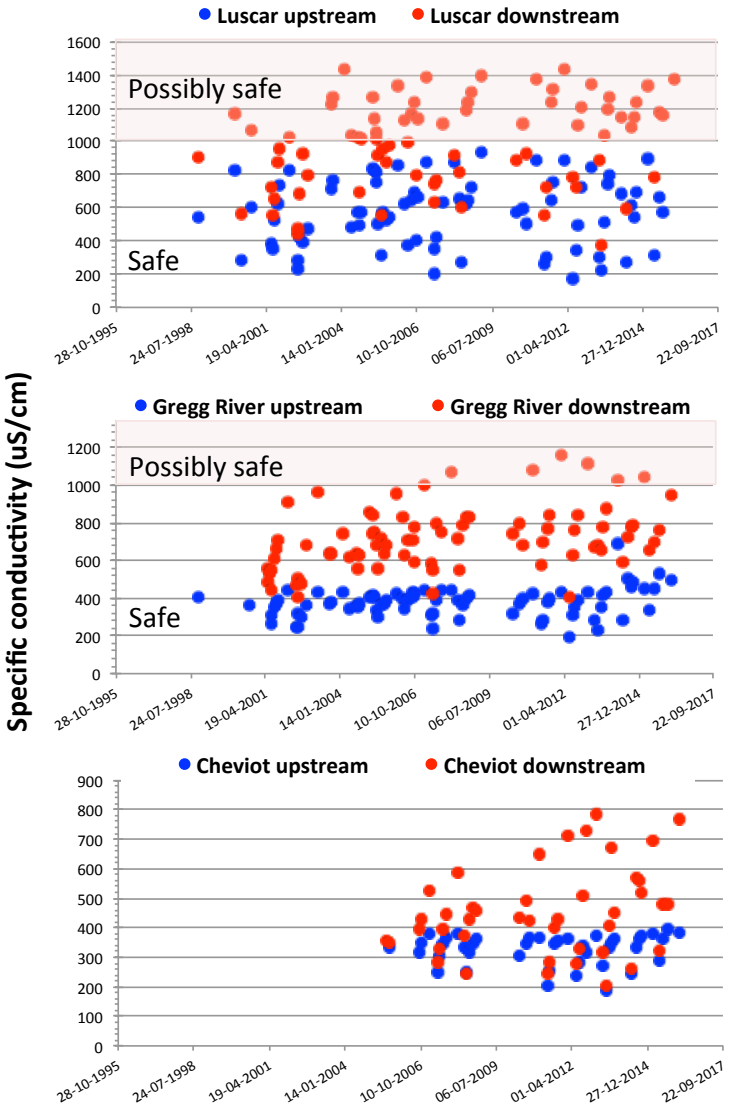
(Data source: Alberta Environment and Parks)

Specific conductance is used to indicate irrigation water quality:

- < 1000 uS/cm = safe for irrigation use
- ≥ 2000 uS/cm = hazardous for irrigation use
- 1000 uS/cm ≤ Sec. Cond. < 2000 uS/cm SAR = "possibly safe" for irrigation purposes (i.e., possibly hazardous)

On average, conductance increased downstream by:

- Luscar mine: +82% (+412 uS/cm)
- Gregg River mine: +94% (+348 uS/cm)
- Cheviot mine: +32% (+128 uS/cm)

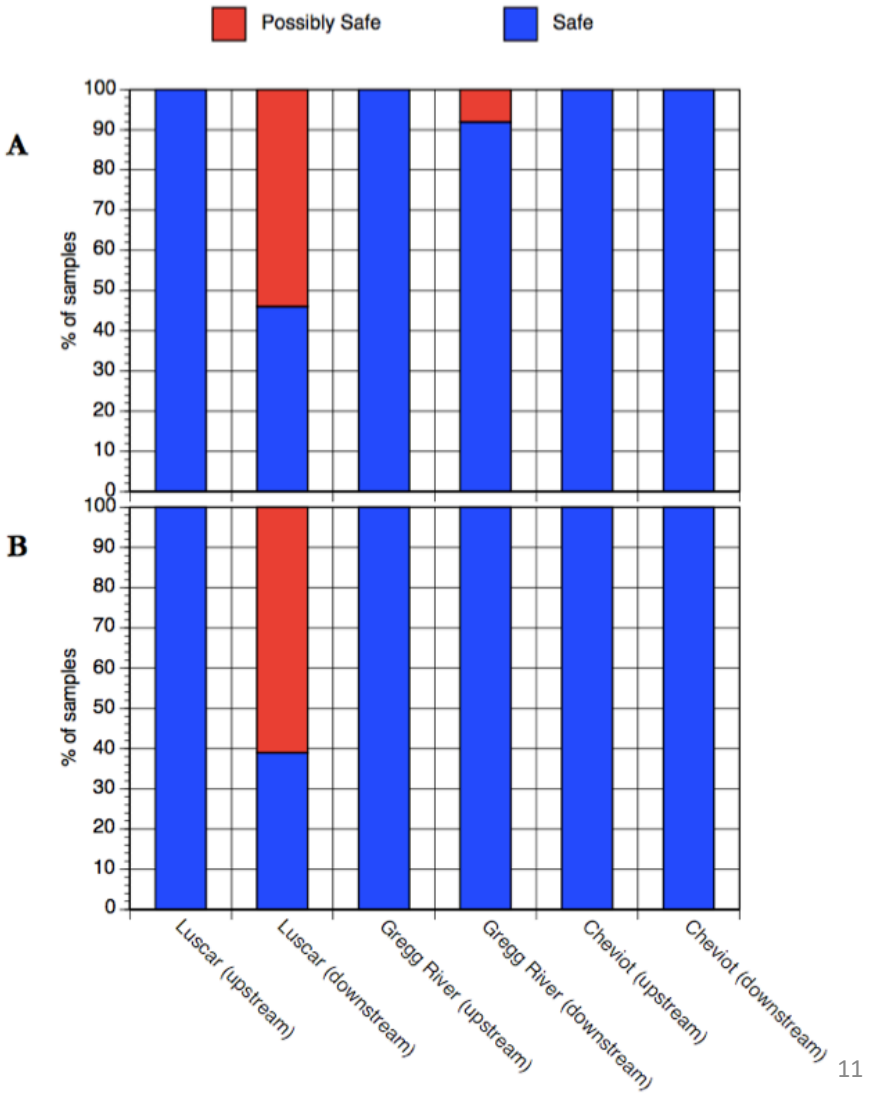


(Data source: Alberta Environment and Parks)

Changes in irrigation water quality downstream of McLeod River watershed coalmines:

A. Conductance increased substantially downstream of all three coal mines, shifting water quality to possibly hazardous for irrigation use 8% of the times downstream of Gregg River mine, and 54% of the time downstream of Luscar mine
B. SAR also shifted from universally safe for irrigation use upstream of Luscar mine, to possibly hazardous for irrigation use 61% of the times sampled downstream of the mine

If similar declines in water quality occur in the headwaters of the Oldman River, what then for downstream Irrigation Districts and farmers?



Metallurgical coal mining in Alberta is a significant risk to aquatic invertebrate communities

- A 2011 survey of benthic invertebrates in reference streams and downstream of coal mines in the upper McLeod watershed and BC's Elk River demonstrated significant declines in density and biodiversity of mayflies, stoneflies and/or caddisflies that corresponded with the degree of physical disturbance caused by coal mines
- Similar changes to invertebrate communities will likely follow the downstream declines in water quality and increases in physical disturbance caused by new coal mining in southwestern Alberta

Metallurgical coal mining in Alberta is a significant risk to downstream fish

- Selenium concentrations in rainbow trout eggs from the upper McLeod River basin in 1999 were higher than in female fish muscle, and both were positively correlated with water concentrations: lowest at undisturbed reference sites and highest downstream of mines (Casey and Siwik 2000).
- Modeling of foodweb effects of bioconcentration and bioaccumulation predicted adverse effects in various fish species in these systems, and laboratory toxicity studies on rainbow trout fry confirmed this conclusion (Casey 2005).
- In 2011, significant increases in selenium concentrations were documented at each level of the aquatic foodchain in the upper McLeod River watershed, including in water, biofilm, invertebrates, and juvenile rainbow and brook trout (Kuchapski and Rasmussen 2015a)
- Average selenium concentrations in muscle in rainbow trout in mine-affected reaches in McLeod River streams exceeded levels expected to cause larval deformities, and up to a 5-fold increase in rainbow trout muscle selenium concentrations corresponded to a 93% decline in total fish biomass (i.e., fewer fish and of smaller size)
- Selenium exposure was the only strong predictor of total fish biomass in each reach, reference and mine-affected streams

Metallurgical coal mining in Alberta is a significant risk to downstream aquatic ecosystem health

- Metallurgical coal mines in the headwater region of the McLeod River have caused clear long-term harm to downstream aquatic ecosystems
- Selenium and other chemical concentrations increased to biologically and ecologically hazardous levels almost immediately after opening (Cheviot mine), during operations of all three mines, and for the entirety of almost two decades of sampling that continued after the closure Gregg River and Luscar mines, and reclamation did not change this
- These sorts of persistent major negative downstream impacts are routinely reported where coal mining occurs, including in the United States, Australia, China, Europe, BC and Alberta, and should be cause for great concern in relation to any new metallurgical coal mines that are considered, planned or approved in the headwater regions of Alberta.